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Environmental and Geotechnical Services

COLSF 7.5 VI

April 16, 1993

**RECEIVED**

APR 19 1993

SUPERFUND BRANCH

Mr. Michael Kuntz  
Washington State Department of Ecology  
Toxics Cleanup Program  
P.O. Box 47600  
Olympia, WA 98504-7600

RE: TRANSMITTAL OF DRAFT TECHNICAL MEMORANDUM  
RELATED TO THE ELIMINATION OF PHOSPHORUS AS A CONSIDERATION  
FOR NPDES SUBSTANTIVE REQUIREMENTS  
ON THE COLBERT LANDFILL RD/RA PROJECT

Dear Mike:

Three copies of the draft technical memorandum concerning the elimination of phosphorus as a consideration for NPDES substantive requirements on the Colbert Landfill RD/RA project are attached. This memorandum is being sent draft at Spokane County's request as Dean Fowler is out of town and was unable to review the document prior to submittal.

Dean will review the document concurrently with Ecology and EPA. Because of the fast-track schedule required to allow project construction this year, a concurrent review is necessary to meet this construction objective. Although Dean's review may result in modification to the memorandum, it is unlikely to significantly change the technical evaluation presented.

Resolution of the phosphorus issue is required by about May 15, 1993, to meet the present construction schedule. Please review this document as soon as possible and indicate (in writing) by May 15, 1993, whether the phosphorus issue is adequately resolved to allow Spokane County to proceed with completion of the final design, and begin the construction phase.

Spokane County has indicated a willingness to meet at any time during the review process to answer questions or discuss any issues that arise. Please contact Dean Fowler or me if you have any questions.

LANDAU ASSOCIATES, INC.

By:

Lawrence D. Beard, P.E.  
Project Manager

LDB/sms

No. 124001.79

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cc: Dean Fowler, Spokane County  
Neil Thompson, EPA

USEPA SF



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Technical Memorandum

TO: Dean Fowler, P.E.  
Spokane County

FROM: Lawrence D. Beard, P.E.  
Landau Associates, Inc.

RE: **EVALUATION OF GROUNDWATER PHOSPHORUS CONCENTRATIONS  
AND PHOSPHORUS FLUX TO THE LITTLE SPOKANE RIVER  
IN THE COLBERT LANDFILL VICINITY**

DATE: April 16, 1993

**1.0 INTRODUCTION**

This memorandum presents Landau Associates' evaluation of groundwater phosphorus concentrations and the flux of phosphorus to the Little Spokane River in the Colbert Landfill vicinity.

The purpose of this memorandum is to assess whether discharge of the extracted groundwater from the Colbert Landfill remedial action project (project) will increase phosphorus loading to the Little Spokane River. If the project does not cause a net increase in phosphorus loading to the Little Spokane River, phosphorus can be eliminated from consideration for the Washington State Department of Ecology's (Ecology) development of National Pollutant Discharge Elimination System (NPDES) substantive requirements for project effluent discharge to the Little Spokane River.

Two questions must be resolved to determine whether the project effluent discharge will affect the net loading of phosphorus to the Little Spokane River:

- Will the project increase the concentration of phosphorus at discharge to the Little Spokane River?
- Will the project increase the net flux of groundwater to the Little Spokane River?

Phosphorus can be eliminated from consideration under NPDES requirements if the answer to both questions is "no". The first question will be evaluated by assessing groundwater quality data to determine if variations in phosphorus data can be attributed to impact by the Colbert Landfill and if phosphorus concentrations are significantly lower near the Little Spokane River than elsewhere in the aquifer(s). The second question will be assessed by evaluating the extent to which groundwater in the Colbert Landfill vicinity recharges the Little Spokane River and whether the project will increase the recharge rate.

The following sections of this memorandum present a brief discussion of the project background, site conditions, and NPDES considerations; a description of groundwater sampling and analyses performed for this evaluation; an evaluation of the impact of the Colbert Landfill on groundwater phosphorus distribution; an assessment of the impact of the project on the net flux of phosphorus to the Little Spokane River; and conclusions and recommendations for addressing the NPDES phosphorus issues.

## **2.0 PROJECT BACKGROUND**

The Colbert Landfill is an inactive, 40-acre, municipal solid waste landfill located approximately 15 miles north-northeast of Spokane, Washington, and 2.5 miles north of Colbert, Washington, as shown on Figure 1. The landfill operated from 1968 until 1986, when it became filled to capacity with municipal and commercial waste.

Groundwater near the landfill is contaminated with chlorinated organic solvents. At least part of this contamination has been traced to spent solvents that were disposed of at the landfill. Solvents were reportedly disposed of at an average rate of several hundred gallons per month for a number of years and primarily consisted of 1,1,1-trichloroethane (TCA) and methylene chloride. Other organic solvents were also detected in groundwater near the landfill, including trichloroethylene, tetrachloroethylene, 1,1-dichloroethylene, and 1,1-dichloroethane. These six chlorinated organic solvents are referred to as the "constituents of concern".

In August 1983, the U.S. Environmental Protection Agency (EPA) placed the landfill on its National Priorities List. Several studies of the landfill were conducted, including the 1987 remedial investigation/feasibility study (Golder Associates 1987a,b). The remedial investigation determined that the two primary aquifers in the landfill vicinity (the Upper and Lower Sand/Gravel Aquifers) were contaminated with some or all of the constituents of concern. The

feasibility study recommended a groundwater extraction and treatment remedy to address this contamination.

EPA released its Colbert Landfill Record of Decision (ROD) for public comment in September 1987 (EPA 1987). Based on recommendations in the feasibility study, the ROD provides for a performance-based remedial action, consisting of a groundwater extraction and treatment system. The remedial action specified in the ROD includes a groundwater extraction system, a treatment system, and a discharge system. The ROD subdivides the extraction system into the following three pumping systems:

- The South Interception System will consist of a series of extraction wells installed to intercept the contaminant plume in the Upper Sand/Gravel Aquifer south of the landfill.
- The West Interception System will consist of a series of extraction wells installed to intercept the contaminant plume in the Lower Sand/Gravel Aquifer west of the landfill.
- The East Extraction System will consist of extraction wells installed near the landfill for source control.

After implementing the ROD, a Consent Decree for the Colbert Landfill was negotiated between the government plaintiffs (EPA and Ecology), and the potentially responsible parties (Spokane County and Key Tronic Corporation). During development of the Consent Decree, it was recognized that available data were inadequate to design the selected remedial action; consequently, the project is being implemented in phases.

Phase I activities were completed in July 1991 and included several activities. Thirty groundwater monitoring wells were constructed at 19 locations for additional hydrogeologic and contaminant distribution characterization. Four pilot extraction wells were constructed for aquifer performance (pumping) tests and as source wells for groundwater treatability studies. Phase I results are provided in the Phase I Engineering Report (Landau Associates 1991).

Phase II design is based on the results of Phase I data and on data collected and analyzed during subsequent hydrogeologic characterization. Design of the Phase II remedial action is almost complete, and a schematic of the Phase II extraction and treatment system is shown on Figure 2.

### 3.0 SITE CONDITIONS

The landfill is located on a plateau that is bounded on the west by a steep slope descending toward the Little Spokane River and on the east by low granite and basalt hills. Surface drainage is to the west toward the Little Spokane River.

The geology of the landfill area consists of a series of glacially and fluvially derived materials deposited on an eroded landscape of clays, basaltic lava deposits, and granitic bedrock. The primary stratigraphic units (layers), from youngest to oldest (i.e., from the top down), are:

- Unit A Upper Sand/Gravel Unit
- Unit B Lacustrine Unit
- Unit C Lower Sand/Gravel Unit
- Unit D Latah Formation
- Unit D<sub>1</sub> Weathered Latah Subunit
- Unit E Basalt Unit
- Unit F Granite Unit.

A generalized east-west profile of these units, based on Phase I data, is shown on Figure 3.

The hydrogeology in the landfill vicinity consists of four aquifers (two primary and two secondary) and three aquitards, as characterized in the Phase I Engineering Report. These units include:

- The Upper Sand/Gravel Unit (Unit A) forms the Upper Sand/Gravel Aquifer when underlain by the Lacustrine Unit (Unit B) and is considered a primary aquifer.
- The Lacustrine Unit (Unit B) is the low-permeability unit that separates the Upper and Lower Sand/Gravel Units and is referred to as the Lacustrine Aquitard. The Lacustrine Aquitard contains water-bearing sand layers and, based on water elevation data, some of the shallow sand layers appear to be in direct hydraulic connection with the Upper Sand/Gravel Aquifer.
- The Lower Sand/Gravel Unit (Unit C) forms the Lower Sand/Gravel Aquifer, which is the second primary aquifer and the regional aquifer for the site.
- The Latah Formation (Unit D) and the Weathered Latah Subunit (Unit D<sub>1</sub>) form the aquitard underlying the Lower Sand/Gravel Aquifer at most locations and (in combination) are referred to as the Latah Aquitard. However, some low-yielding private wells are installed in the Latah Aquitard to the east of the landfill, where the Upper and Lower Sand/Gravel Aquifers are not present.

- The Basalt Unit (Unit E) forms a secondary aquifer interbedded with the Latah Aquitard and is referred to as the Basalt Aquifer.
- The Granite Unit (Unit F) serves as the lower boundary (aquitard) to the regional flow system, although some low-productivity wells are installed in the upper portion of this unit.
- The Fluvial Unit, associated with the Little Spokane River, forms the Fluvial (secondary) Aquifer. The Fluvial Aquifer may be in direct hydraulic connection with the Lower Sand/Gravel Aquifer, but piezometric and contaminant migration data (as discussed in the Phase I Engineering Report) suggest that it can be treated as an independent hydrogeologic unit for the purposes of this project.

Units C, D, E, and F are collectively referred to as the "Lower Aquifers" for evaluating regional groundwater flow and contaminant distribution, although the Lower Sand/Gravel Aquifer (Unit C) appears to be the only one of these units capable of sustaining significant discharge rates.

The Upper Sand/Gravel Aquifer is unconfined, with a depth to water about 90 ft below ground surface in the landfill vicinity. The thickness of the Upper Sand/Gravel Aquifer varies from about 8 to 20 ft along its north-south trending centerline and decreases as it extends toward the western bluff and eastern hills. Upper Sand/Gravel Aquifer groundwater flow is predominantly toward the south, with velocities ranging from about 5 to 7 ft per day (Landau Associates 1991). A groundwater elevation contour map for the Upper Sand/Gravel Aquifer is shown on Figure 4.

The Lower Sand/Gravel Aquifer is generally confined west of the landfill and unconfined from the west landfill boundary to the east. The potentiometric surface of the Lower Sand/Gravel Aquifer is about 180 ft below ground surface, and the saturated thickness varies from less than 1 ft east of the landfill to over 200 ft near U.S. Highway 2. Groundwater in the Lower Sand/Gravel Aquifer flows predominantly toward the west, at velocities ranging from about 0.3 to 0.6 ft per day (Landau Associates 1991).

East of the Lower Sand/Gravel Aquifer, groundwater flow occurs primarily as perched groundwater at the Lower Sand/Gravel Unit interface with the underlying Latah Aquitard and within the Basalt (secondary) Aquifer. A groundwater elevation contour map for the combined Lower Aquifers is shown on Figure 5.

The Upper Sand/Gravel Aquifer, Fluvial Aquifer, and shallow sand interbeds of the Lacustrine Aquitard are collectively referred to as the Upper Aquifers for assessing the distribution of constituents of concern in groundwater. The distribution of the constituents of concern for the Upper and Lower Aquifers is shown on Figures 6 and 7, respectively. These figures are based on a composite of groundwater quality data collected through 1991, and represent the areal extent over which one or more of the constituents of concern were detected and the area over which one or more of the constituents of concern exceed the cleanup criteria.

A more thorough discussion of hydrogeologic and water quality conditions is presented in Section 4.0 of the Phase I Engineering Report.

#### **4.0 NPDES CONSIDERATIONS**

In June 1992, Ecology requested that Spokane County evaluate background groundwater quality in the landfill vicinity for Ecology's use in developing the substantive NPDES permit requirements for project discharges to the Little Spokane River. Although Spokane County did not (and does not) concur that additional evaluation was needed, they performed the additional sampling and analyses requested by Ecology to avoid delaying the project. Sampling was performed in late July 1992, and results of the background water quality assessment are presented in a Landau Associates September 25, 1992 technical memorandum (revised February 8, 1993).

Ecology provided review comments on the September 25, 1992 technical memorandum in a December 22, 1992 letter. Many of the NPDES issues initially identified by Ecology were resolved by the additional evaluation. However, the estimated Phase II effluent concentration for total phosphorus (about 0.6 mg/L) was identified by Ecology as exceeding the state water quality criterion for total phosphorus, based on the phosphorus criteria established for the Long Lake reach of the Spokane River (0.025 mg/L).

Spokane County does not concur that the Ecology-proposed phosphorus criterion is applicable to project discharges. However, Ecology and Spokane County agreed that phosphorus can be eliminated from further consideration for project discharges, provided it can be demonstrated that project discharges will not cause a net increase in phosphorus loading to the Little Spokane River.



## 5.0 GROUNDWATER SAMPLING AND ANALYSIS

Groundwater samples were collected from 13 groundwater monitoring wells, shown on Figure 8, to evaluate whether the phosphorus concentrations in the landfill vicinity are related to background conditions. Nine of these wells are located in areas that represent background conditions (CD-5, CD-32A, CD-36A, CD-38A, CD-40C2, CD-43C2, CD-44C2, CD-45C2, and CD-48C2), and four wells are located within areas impacted by the Colbert Landfill (CD-21C1, CD-30A, CD-46C2, CD-47C2). At locations where multiple wells exist, the well screened near the center of the aquifer was sampled because it should best represent average aquifer conditions.

The designation of background wells is based on results of previous water quality monitoring. Many of the background wells are located crossgradient or downgradient from the landfill, but outside the area impacted by the landfill. This approach was taken because the Upper and Lower Sand/Gravel Aquifers, the primary aquifers of interest, are not present upgradient of the landfill, and adequate water quality data are available to distinguish between areas of the aquifers impacted and not impacted by the landfill.

Samples were collected between February 23, 1993, and March 3, 1993, and analyzed for total phosphorus (EPA Method 365.3). A quality assurance/quality control review (data validation) of the analytical data was performed using EPA guidelines (EPA 1988a); data qualifiers are provided following EPA Contract Laboratory Program (CLP) guidelines (EPA 1988a). The data validation considered the following elements:

- Holding times
- Detection limits
- Surrogate recoveries
- Matrix spike results
- Blank analysis results
- Duplicate analysis results
- Data completeness.

All data meet validation guidelines, and no data were rejected as a result of the data validation.

Analytical results are summarized in Table 1. Table 1 also includes the total phosphorus analytical results for samples collected during the July 1992 assessment of site water quality conditions, although samples were only collected for the nonbackground wells at that time.



Because the total phosphorus concentration for Background Well CD-48C2 was significantly higher than concentrations for both background and nonbackground wells, the well was resampled March 18, 1993. Both filtered and unfiltered samples were collected to confirm that suspended sediment was not the cause of the previously measured elevated phosphorus concentration. The total phosphorus concentration is slightly lower for the second sampling, but not sufficiently lower to suggest that the initial sampling result is anomalous. Similarly, the filtered sample result is slightly lower than the unfiltered sample result, but not sufficiently lower to suggest that the high phosphorus concentration results from suspended sediment.

## **6.0 EVALUATION OF GROUNDWATER PHOSPHORUS DATA**

Phosphorus background conditions for groundwater were evaluated to assess whether the landfill has impacted phosphorus concentrations. This evaluation includes an assessment of whether a significant statistical difference between background and nonbackground phosphorus data sets exists and an assessment of how well phosphorus concentrations correlate to specific conductance (a parameter that correlates strongly to the presence of landfill leachate).

### **6.1 CORRELATION OF BACKGROUND AND NONBACKGROUND PHOSPHORUS DATA**

If the landfill has significantly impacted groundwater phosphorus concentrations, a comparison of phosphorus data collected from background and nonbackground monitoring wells should reveal a discernable difference between the data sets. The distribution of the phosphorus data for background and nonbackground wells is shown on Figure 9. Qualitative assessment of these data suggests that the range in background and nonbackground phosphorus concentrations is similar, indicating the data are derived from the same population. This qualitative assessment supports the conclusion that the Colbert Landfill has not impacted groundwater phosphorus concentrations. However, statistical analyses are presented in the following subsections to confirm and better quantify this qualitative assessment.

Before statistically evaluating the potential impact of the landfill, other sources of potential variability in the phosphorus groundwater quality data were evaluated. Five wells (CD-30A, CD-21C1, CD-46C2, CD-47C2, and CD-48C2) were sampled on more than one occasion, and duplicate samples were collected from two of these wells (CD-46C2 and CD-47C2). The variability in phosphorus concentration for the multiple sampling events at each of these wells

(including duplicate analyses) is shown on Figure 10 (three data points are presented for Wells CD-46C2 and CD-47C2, but only two data points are discernable on Figure 10 because of identical results for each pair of duplicate sample results). A visual comparison of the data variability at each well indicates that the intrawell variability is relatively small compared to the interwell variability. Based on this graphical evaluation, the phosphorus data are considered sufficiently representative and reproducible for comparison of background and nonbackground water quality data. For subsequent analyses, the phosphorus concentration is represented by an average of the data at wells where multiple sampling has occurred.

#### 6.1.1 Statistical Approach

A statistical approach appropriate for assessing a potential impact from a site such as the Colbert Landfill is discussed in EPA statistical guidance for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; EPA 1988) and Resource Conservation and Recovery Act (RCRA; EPA 1989) programs. This approach consists of the following steps:

- Establish the null hypothesis
- Analyze the data to determine the data distribution and to choose an appropriate statistical test
- Apply the statistical test
- Reject or accept the null hypothesis based on the outcome of the test.

The null hypothesis ( $H_0$ ) is what is assumed to be true about the system under study prior to data collection, until indicated otherwise (Helsel and Hirsch 1992; EPA 1988b). The alternate hypothesis ( $H_1$ ) is accepted if the data indicate that the null hypothesis is unlikely. The null and alternate hypotheses for evaluating the potential impact of the Colbert Landfill on groundwater phosphorus concentrations are:

- $H_0$ : The mean phosphorus concentrations of the background and nonbackground wells are the same (i.e., no impact from the Colbert Landfill).
- $H_1$ : The mean phosphorus concentration of the nonbackground wells is greater than the mean concentration of background wells (i.e., the Colbert Landfill has impacted phosphorus concentrations).

Statistical tests are discussed in both RCRA (EPA 1989, 1992) and CERCLA (EPA 1988b) statistical guidance. The RCRA guidance focuses on describing statistical procedures to determine an impact from a facility. The CERCLA guidance describes statistical procedures that are used to determine if groundwater attains cleanup standards after remedial action (EPA 1988b). Therefore, statistical tests provided in the RCRA guidance are more appropriate than the CERCLA guidance for testing the null hypothesis for this project.

The RCRA guidance recommends using a one-way analysis of variance (ANOVA) to test the null hypothesis stated above. The use of the ANOVA requires that the data be lognormally (or normally) distributed and the variances of the background and nonbackground data sets be approximately equal.

#### **6.1.2 Data Distribution**

Water quality data are typically assumed to be lognormally distributed (EPA 1992; Ecology 1992). To test the assumption of lognormality, the natural logarithm (ln) of phosphorus concentrations versus the cumulative percent occurrence were plotted for background and nonbackground data, as shown on Figures 11 and 12, respectively. These data plot on approximately a straight line, which indicates that they are approximately lognormally distributed.

The assumption of lognormality was quantitatively verified by applying the Shapiro-Wilkes (W) test (EPA 1992; Ecology 1992). The results of this test indicate that the data are lognormally distributed at a confidence level of 95 percent (an alpha level of .05). Results of the W-test are provided in Table 2.

#### **6.1.3 Variance of Data Sets**

Equality of background and nonbackground data set variances can be estimated by comparing box plots of the data. If the box length (the range between the 25 percent and 75 percent quartiles) for one group of data is less than 3 times the box length for the other data set, the sample variances can be considered approximately equal (EPA 1992). Box plots of background and nonbackground data sets are presented on Figure 13. The length of the boxes are approximately equal, indicating the variances of the background and nonbackground data sets are similar enough for application of the ANOVA test.

The qualitative assessment of variance by inspection of box plots was confirmed by applying Bartlett's test for homogeneity of variances (EPA 1989). The results of this test indicate that the variances are equal, at a confidence level of 95 percent (an alpha level of .05). Results of Bartlett's test are shown in Table 3.

#### **6.1.4 ANOVA Analysis**

The ANOVA test was deemed appropriate for application to the background and nonbackground data sets because they are lognormally distributed and have similar variances. EPA guidance indicates that the null hypothesis (that the mean concentrations for samples from the background and nonbackground wells are the same) is accepted if the F-statistic calculated by the ANOVA test is less than the tabulated F-value (EPA 1989). The null hypothesis can also be evaluated based on the attained significance level for the correlation of the two data sets. The null hypothesis is accepted if the attained significance level is above the alpha level of 0.05 (EPA 1989).

The ANOVA F-statistic and attained significance level results strongly support the contention of the null hypothesis because they passed their respective criterion by a wide margin. The calculated F-statistic for the background and nonbackground wells is 0.031, which is appreciably lower than the tabulated F-value of 4.75. The attained significance level calculated for the comparison of background and nonbackground data sets is 0.86, which is appreciably greater than the 0.05 required to accept the null hypothesis. Consequently, the null hypothesis is accepted, and it is concluded that there is no significant difference in phosphorus concentration between the background and nonbackground data sets (i.e., they come from the same population). This analysis indicates that there is no evidence that the landfill is impacting groundwater quality with respect to phosphorus.

#### **6.2 CORRELATION OF PHOSPHORUS AND SPECIFIC CONDUCTANCE DATA**

A commonly observed impact of a landfill leachate on groundwater is an increase in groundwater specific conductance. This effect was observed during the Phase I investigation (Landau Associates 1991) and is being used during Phase II well construction to identify aquifer zones impacted by landfill leachate (Landau Associates 1992a,b). Consequently, a significant

correlation should exist between phosphorus concentration and specific conductance if the landfill has impacted groundwater phosphorus concentrations.

#### **6.2.1 TCA Versus Specific Conductance**

TCA is the most widely distributed constituent of concern in the Colbert Landfill vicinity. As a result, specific conductance should correlate to TCA if specific conductance is impacted by the landfill. TCA concentrations generally increase with increasing specific conductance for TCA concentrations above about 10 µg/L, as shown on Figure 14.

A regression analysis was performed to quantify the relationship between specific conductance and TCA above 10 µg/L; the least-squares best-fit line is shown on Figure 15. The regression analysis results in a correlation coefficient of 0.78, which indicates a strong correlation between TCA and specific conductance; a value of 1 indicates a perfect correlation, a value of 0 indicates no correlation. Additionally, the regression analysis R-squared value indicates that over 60 percent of the variability in specific conductance can be attributed to the relationship between specific conductance and TCA concentration. These statistics strongly support specific conductance as an indicator of the impact of the landfill on groundwater.

#### **6.2.2 Phosphorus Versus Specific Conductance**

A relationship between specific conductance and phosphorus concentration does not appear to exist, as shown on Figure 16. A regression analysis was performed to quantify the relationship between specific conductance and phosphorus; the least-squares best-fit line is shown on Figure 16. The flat (slightly negative) slope of the best-fit line indicates there is no tendency for specific conductance to increase with increasing phosphorus concentration. The regression analysis indicates a correlation coefficient of -0.025, which is indicative of no relationship between the two variables. Additionally, the R-squared value indicates that only 0.06 percent of the variability in specific conductance can be attributed to the relationship between phosphorus concentration and specific conductance. These statistics strongly support the conclusion that the landfill has not impacted groundwater phosphorus concentrations.

## **7.0 NET PHOSPHORUS FLUX TO THE LITTLE SPOKANE RIVER**

The groundwater phosphorus flux to the Little Spokane River is dependent upon the phosphorus concentration and volumetric flow rate of the discharge water. If the project does not increase the phosphorus concentration or the volumetric flow rate of the discharge water, the net phosphorus flux to the Little Spokane River is unaffected by the project. Therefore, it is necessary to demonstrate that the groundwater phosphorus concentration is not increased by extracting groundwater near the Colbert Landfill (and discharging via pipeline to the Little Spokane River) above that concentration which occurs when groundwater discharges naturally (under nonpumping conditions), and that the extracted groundwater would have discharged to the Little Spokane River under nonpumping conditions.

The following subsections address these issues. The effect of the Colbert Landfill on groundwater phosphorus concentrations is primarily addressed in Section 6, but the potential effect of groundwater extraction and discharge versus natural flow to the Little Spokane River (independent of specific landfill impacts on groundwater) is evaluated in this section. The effect of the project on the volumetric flow rate includes consideration of the aquifer recharge rate to the Little Spokane River and the net impact of the extraction system on river recharge, and is also addressed in this section.

### **7.1 PHOSPHORUS CONCENTRATION DISCHARGING TO THE LITTLE SPOKANE RIVER**

The flux of phosphorus to the Little Spokane River from groundwater is a function of the groundwater flux rate and the groundwater phosphorus concentration at the discharge point. Under long-term, steady-state conditions, the flux of phosphorus discharging to the Little Spokane River via groundwater should be equivalent to the flux of phosphorus entering the aquifer, provided the liquid/solid phase equilibrium between the groundwater and the aquifer soil matrix remains constant. Therefore, a change in phosphorus flux to the Little Spokane River should only occur if the rate of phosphorus recharge to the aquifer changes, the phosphorus equilibrium within the aquifer varies spatially, or the rate of groundwater flux changes. As previously discussed in Section 6.0, it does not appear that the landfill is impacting groundwater phosphorus concentrations; therefore, an increase in phosphorus recharge to groundwater is not anticipated, and if it occurred, would be unrelated to the project.

Comparison of groundwater phosphorus concentrations near the Little Spokane River to the median concentration determined from groundwater phosphorus data provides a basis for assessing whether phosphorus equilibrium conditions are significantly different near the Little Spokane River than for average groundwater conditions. Monitoring Well CD-40C2 is about 600 ft from the Little Spokane River and is the closest location to the river sampled for phosphorus as part of this evaluation. A phosphorus concentration of 0.15 mg/L was measured for the groundwater sample collected from Monitoring Well CD-40C2. The median phosphorus concentration (50 percent cumulative occurrence) for the background wells is about 0.18 mg/L (ln -1.7), as shown on Figure 11. Therefore, the groundwater phosphorus concentration near the Little Spokane River is approximately equal to the median concentration for the background wells.

The similarity of measured phosphorus concentration near the Little Spokane River and the median value suggests that groundwater phosphorus equilibrium near the Little Spokane River represents typical (median) conditions for the aquifer. Therefore, extracting groundwater farther upgradient and discharging it via pipeline to the Little Spokane River should not significantly affect phosphorus equilibrium conditions, provided phosphorus equilibrium is not affected by the landfill.

Because the statistical analyses presented in Section 6.0 support the conclusion that the landfill has not impacted groundwater phosphorus concentrations, it is reasonable to conclude that phosphorus equilibrium conditions near the landfill are similar to those near the Little Spokane River. Therefore, if the groundwater discharge rate to the Little Spokane River is not changed by the project, the flux of phosphorus to the Little Spokane River should not be changed. The following section addresses the impact of the project on groundwater discharge to the Little Spokane River.

## 7.2 AQUIFER RECHARGE

Ecology evaluated the hydrology of the Little Spokane River basin as part of its water resources management program (Ecology 1975). Information and analyses from this evaluation indicate that the Little Spokane River is the primary receptor for groundwater and surface water within the Little Spokane River basin and supports significant groundwater recharge to the Little Spokane River from the landfill vicinity.



Ecology reports that, although tributary streams suffer extreme low flows during the summer months, the main stem of the Little Spokane River maintains a relatively high stream flow due to groundwater recharge (Ecology 1975). Ecology also concludes that almost all the summer instream flow at the Dartford gauging station (about 110 cfs) results from groundwater recharge.

A comparison of base flows measured during low flow months at gauging stations upstream and downstream of the landfill provide a basis for estimating groundwater recharge to the Little Spokane River from the landfill vicinity. The summer base flow and river mile values for the Dartford and Chattaroy gauging stations (Ecology 1975) are:

Gauging Station	River Mile (miles)	Base Flow <sup>(a)</sup> (cfs)
Dartford	10.8	115
Chattaroy	23.05	57

(a) August value.

The Colbert Landfill is due east of river mile 20.

The difference in base flow between the gauging stations (115 - 57 cfs) divided by the difference in river miles (20.05 - 10.8 miles) is a reasonable estimate of the groundwater recharge per river mile (6.3 cfs/mile). Assuming about half of the recharge originates from the east side of the Little Spokane River, it is estimated that groundwater from the landfill vicinity contributes slightly more than 3 cfs (about 1,400 gpm) of recharge per river mile.

The primary source of groundwater flux to the Little Spokane River in the landfill vicinity is the Lower Sand/Gravel Aquifer. Although the Upper Sand/Gravel Aquifer flows primarily to the south (parallel to the Little Spokane River) in the Colbert Landfill vicinity, it also discharges to the Little Spokane River via springs along the east margin of the aquifer (Landau Associates 1991). Additionally, the Upper Sand/Gravel Aquifer ultimately discharges (directly or indirectly) to the Little Spokane River between the landfill and Deadman Creek to the south (Golder Associates 1987b). However, because the Upper Sand/Gravel Aquifer contributes less than 20 percent to the maximum estimated project discharge and does not generally exhibit phosphorus concentrations significantly above concentrations of concern, the evaluation of

groundwater recharge to the Little Spokane River will only address recharge from the Lower Sand/Gravel Aquifer.

The Lower Sand/Gravel Aquifer groundwater recharge to the Little Spokane River from the landfill vicinity was estimated to be about 5.5 cfs for a 2.5 mile width of aquifer, based on data collected during the Phase I investigation (Landau Associates 1992b). This is equivalent to a recharge rate of about 2.2 cfs (about 1,000 gpm) per mile of aquifer width. Although slightly lower, this estimate is consistent with the average recharge rate of 3 cfs estimated from the Ecology data.

### **7.3 PROJECT EXTRACTION RATE**

It is estimated that a combined groundwater extraction rate for the West and East Interception Systems of about 750 gpm will be required to achieve the 0.75 mile wide capture zone needed for the Lower Sand/Gravel Aquifer (Landau Associates 1992b). This estimated groundwater extraction rate is 750 gpm lower than the maximum estimated discharge rate of 1,500 gpm to the Little Spokane River. The estimated extraction rate of 280 gpm for the Upper Sand/Gravel Aquifer (South) Interception System partially accounts for this difference. The remaining 470 gpm associated with the maximum estimated discharge rate is additional system capacity to address uncertainties in aquifer properties and the potential need for future system expansion.

### **7.4 EFFECT OF EXTRACTION SYSTEM ON GROUNDWATER RECHARGE**

The estimated extraction rate of 750 gpm for the Lower Sand/Gravel Aquifer is equal to an average extraction rate of 1,000 gpm per mile of aquifer width, for the 0.75 mile wide capture zone. This extraction rate is equal to the groundwater recharge rate of 1,000 gpm per mile of aquifer width estimated from Phase I data (Landau Associates 1992b). As a result, it is anticipated that the project groundwater extraction rate will be approximately equal to the aquifer recharge within the capture zone, and a significant net increase in groundwater recharge to the Little Spokane River will not result from operation of the project.

## 8.0 CONCLUSIONS AND RECOMMENDATIONS

The potential for project effluent discharge to affect the net loading of phosphorus to the Little Spokane River was evaluated to determine whether phosphorus can be eliminated from consideration under NPDES substantive requirements. This was evaluated by responding to two questions:

- Will the project increase the concentration of phosphorus at discharge to the Little Spokane River?
- Will the project increase the net flux of groundwater to the Little Spokane River?

The answer to both of these questions is "no," based on the evaluation of groundwater phosphorus concentrations and the evaluation the flux of groundwater to the Little Spokane River. Therefore, phosphorus should be eliminated from consideration under NPDES.

The similarity of background and nonbackground groundwater phosphorous data sets and the lack of a relationship between phosphorus concentrations and specific conductance, strongly support the conclusion that groundwater phosphorus concentrations in the Colbert Landfill vicinity are a background condition unrelated to the Colbert Landfill. Also, the groundwater phosphorus concentration near the Little Spokane River is approximately equal to the median groundwater concentration for phosphorus, which suggests that a significant reduction in phosphorus concentration is not occurring in the aquifer between the landfill and the Little Spokane River.

The groundwater discharge rate to the Little Spokane River should not increase due to the project. Data analyses indicate that the average recharge rate to the Little Spokane River from groundwater is approximately equal to the anticipated project extraction rate from the portion of Lower Sand/Gravel Aquifer within the project capture zone.

The assessment contained in this memorandum demonstrates that observed phosphorus concentration for groundwater in the Colbert Landfill vicinity is a background condition unrelated to landfill activities and that the net flux of phosphorus to the Little Spokane River should be unaffected by project operation. As with any evaluation of this nature, uncertainties exist. Verification of the conclusions reached in this assessment can only be achieved by monitoring the operation of the project and evaluating resulting data. Consequently, it is

recommended that the project be constructed and its effect on phosphorus concentrations in the Spokane River be evaluated during steady-state operation.

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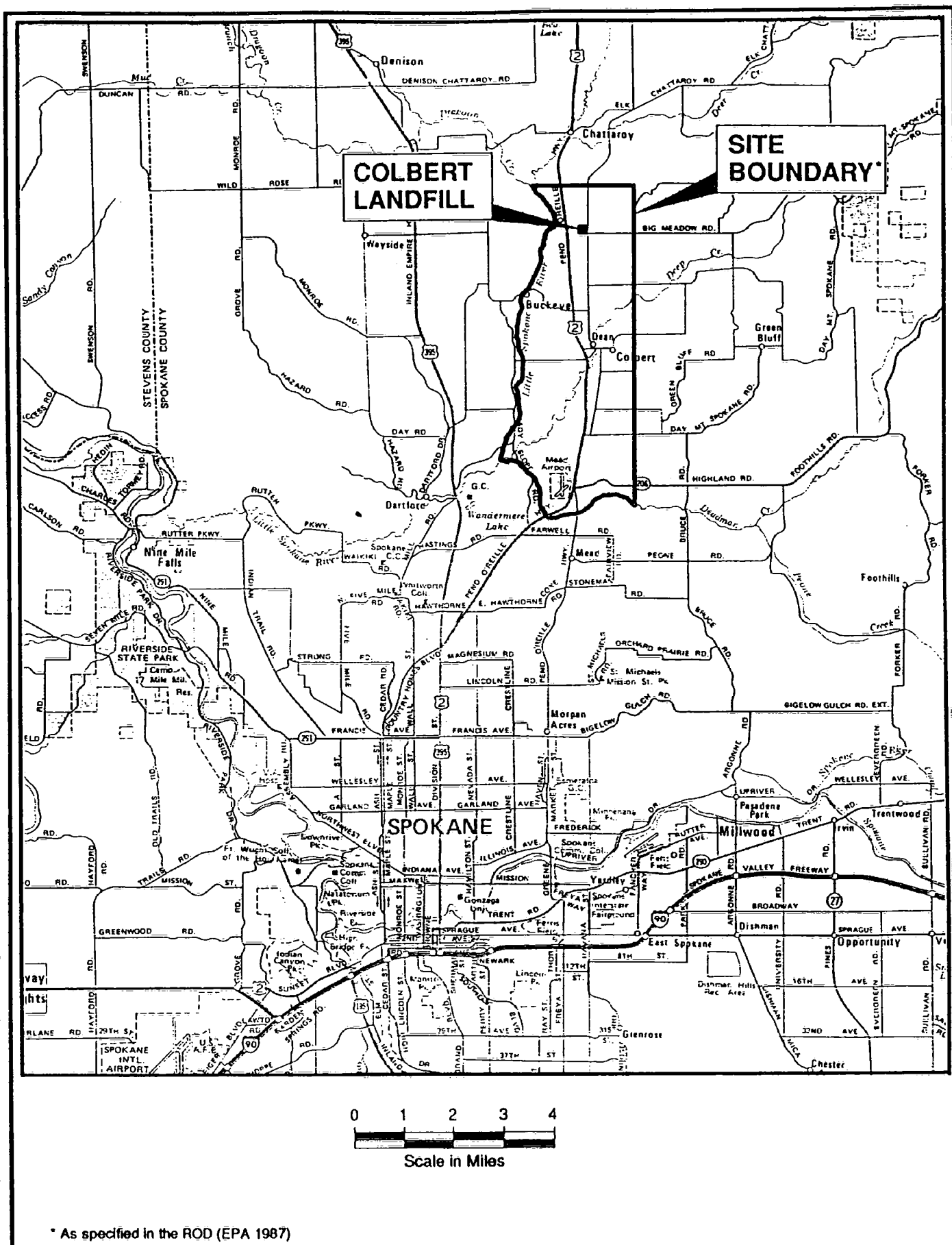
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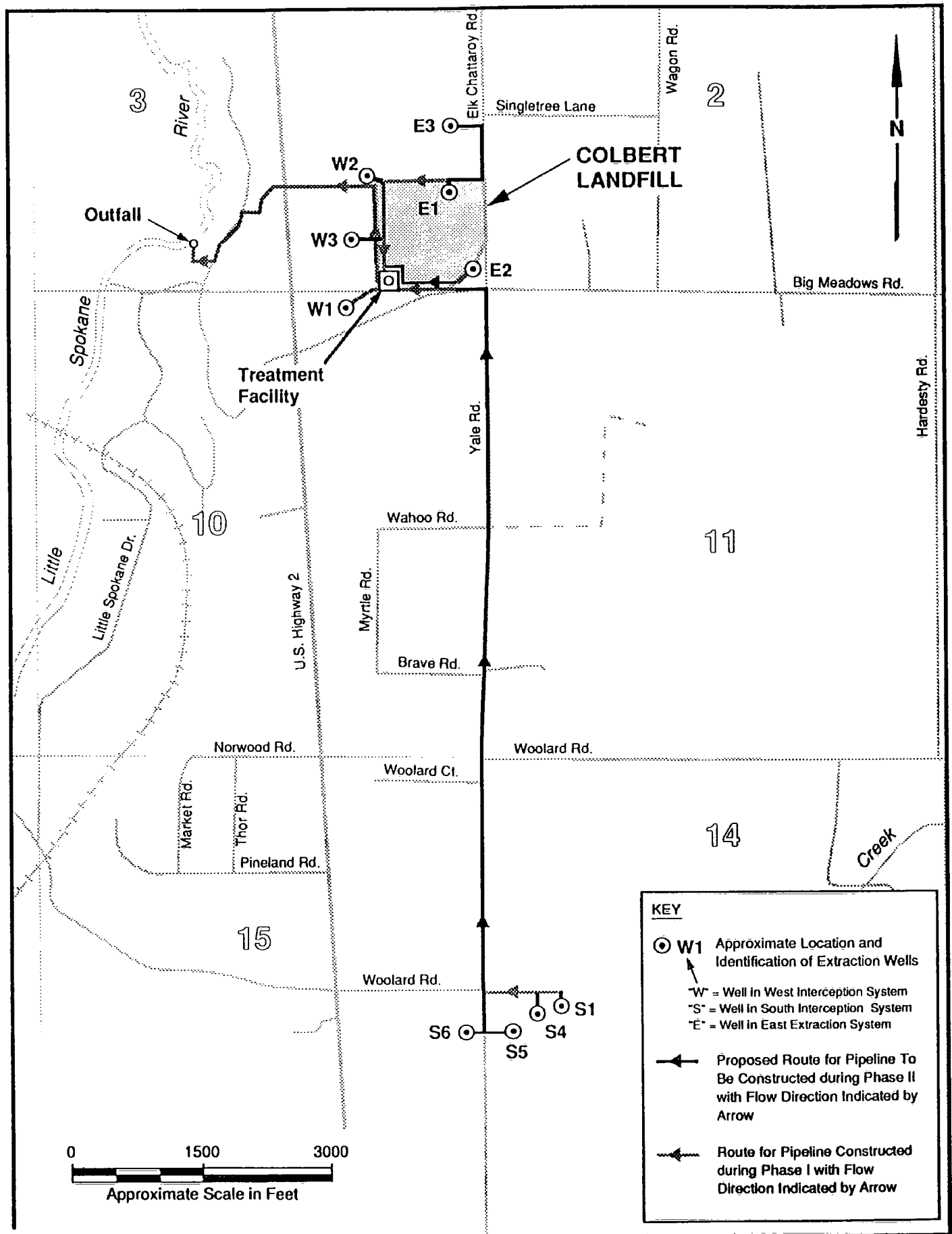


\* As specified in the ROD (EPA 1987)



Regional Location Map

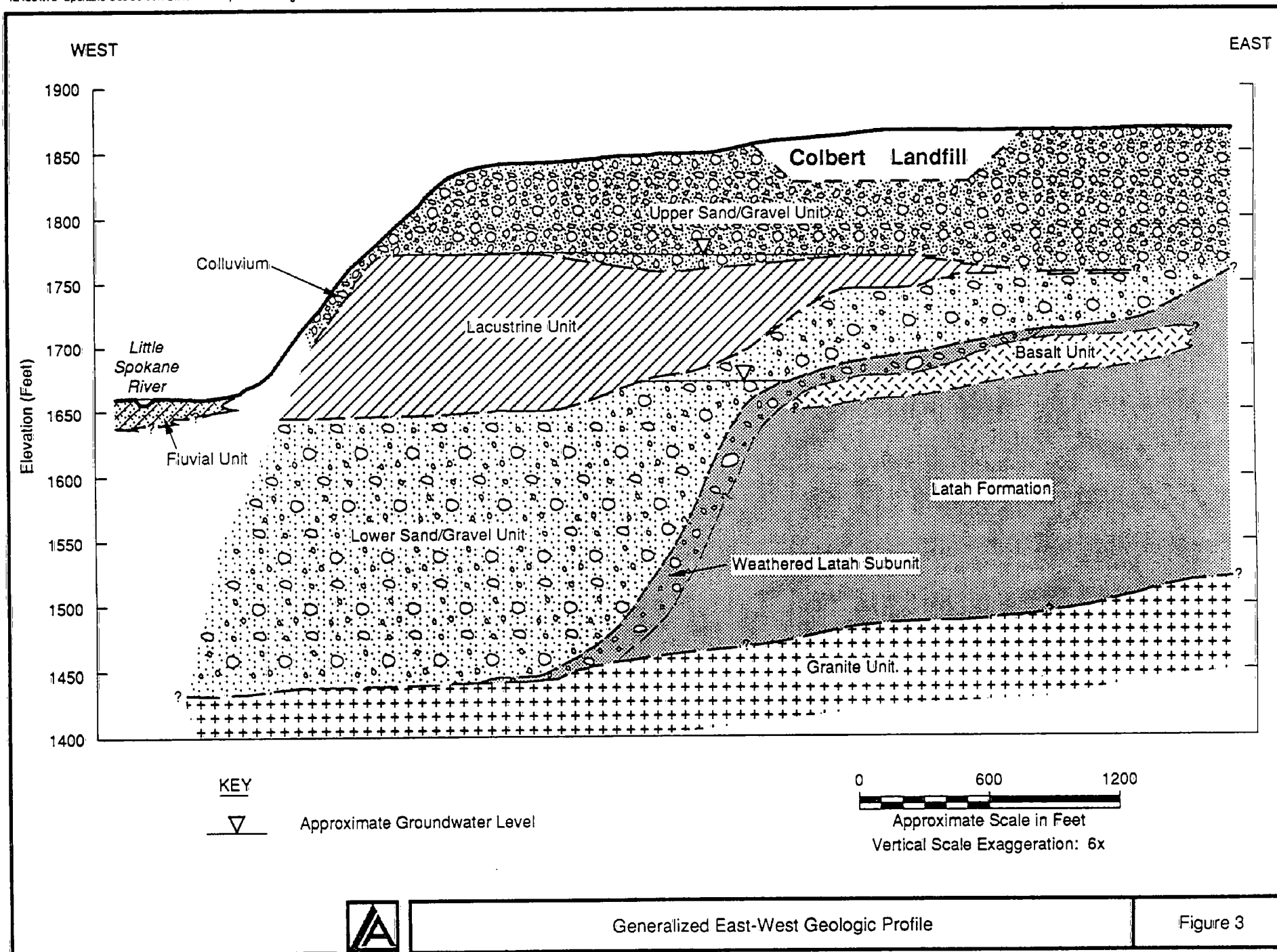
Figure 1

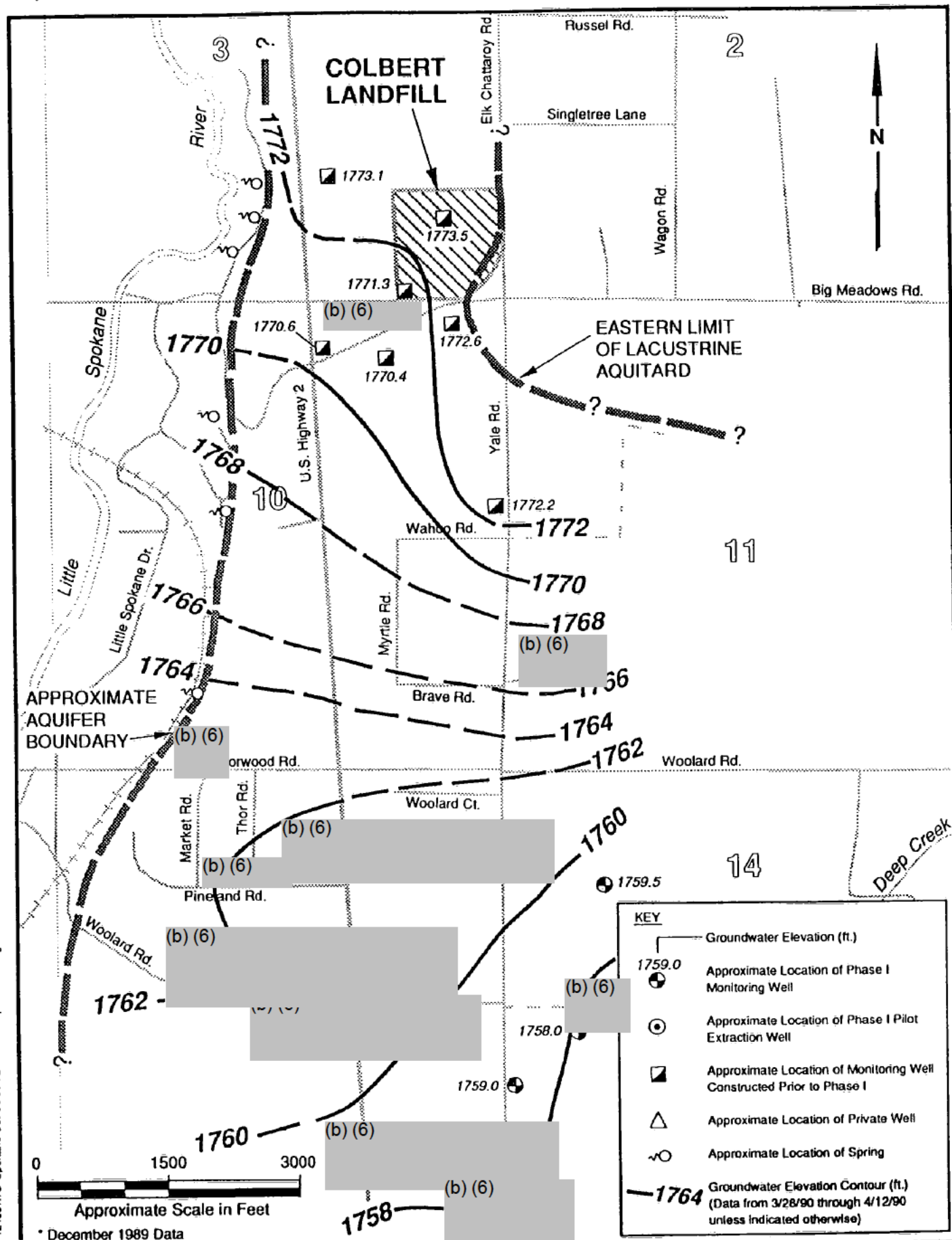


Planned Phase II Extraction and Treatment System Schematic

Figure 2

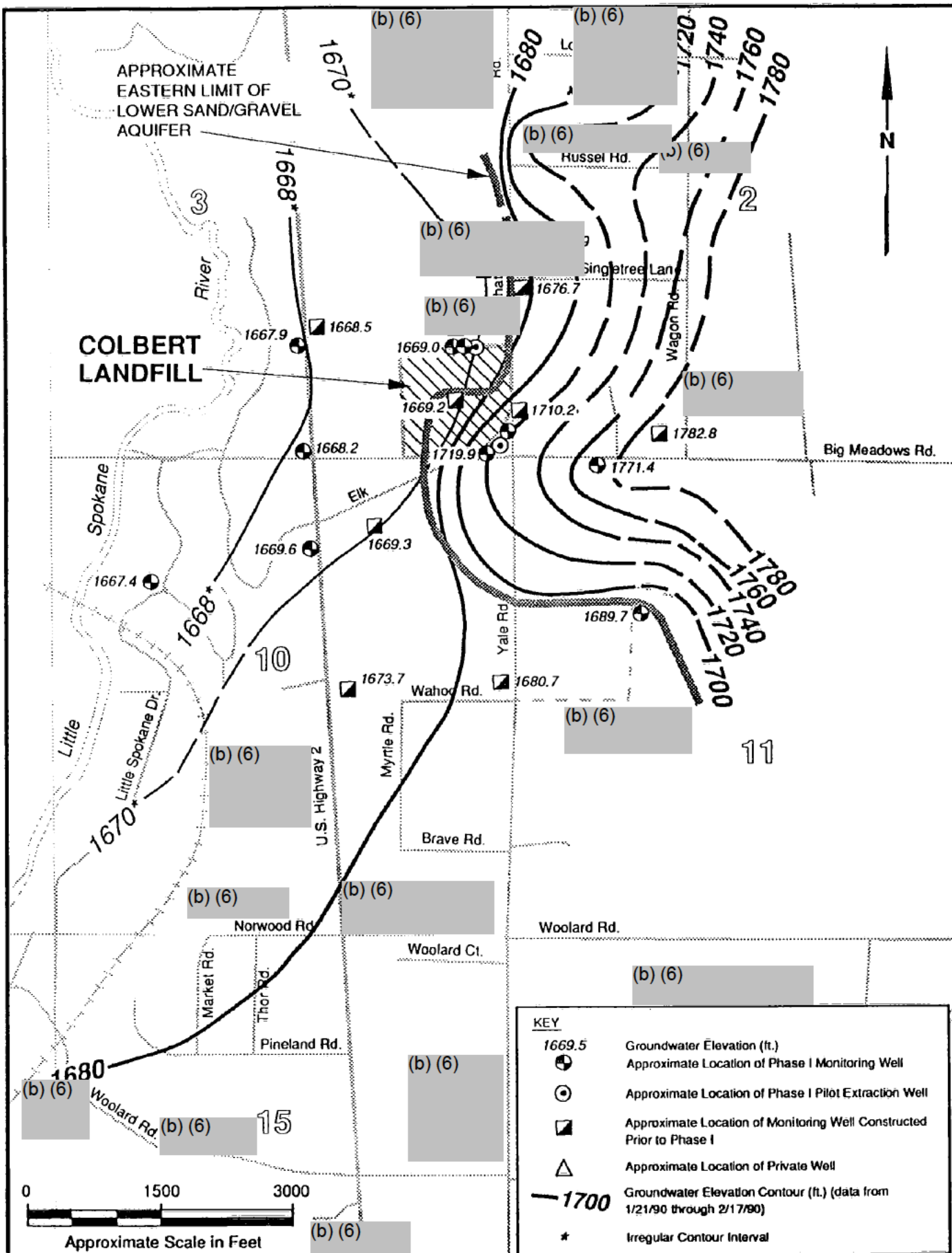






Upper Sand/Gravel Aquifer  
Groundwater Elevation Contours

Figure 4



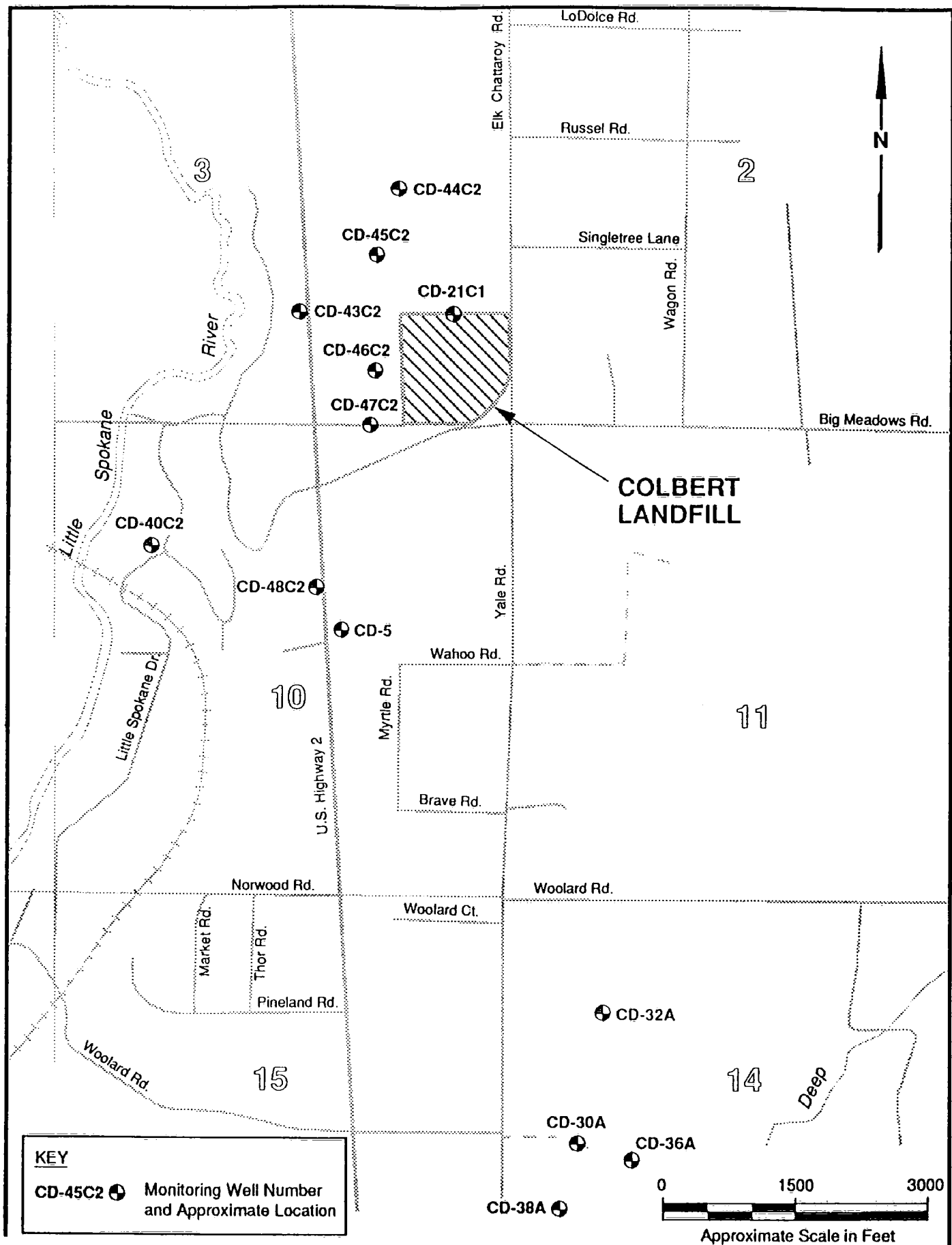
Lower Aquifers  
Groundwater Elevation Contours

Figure 5



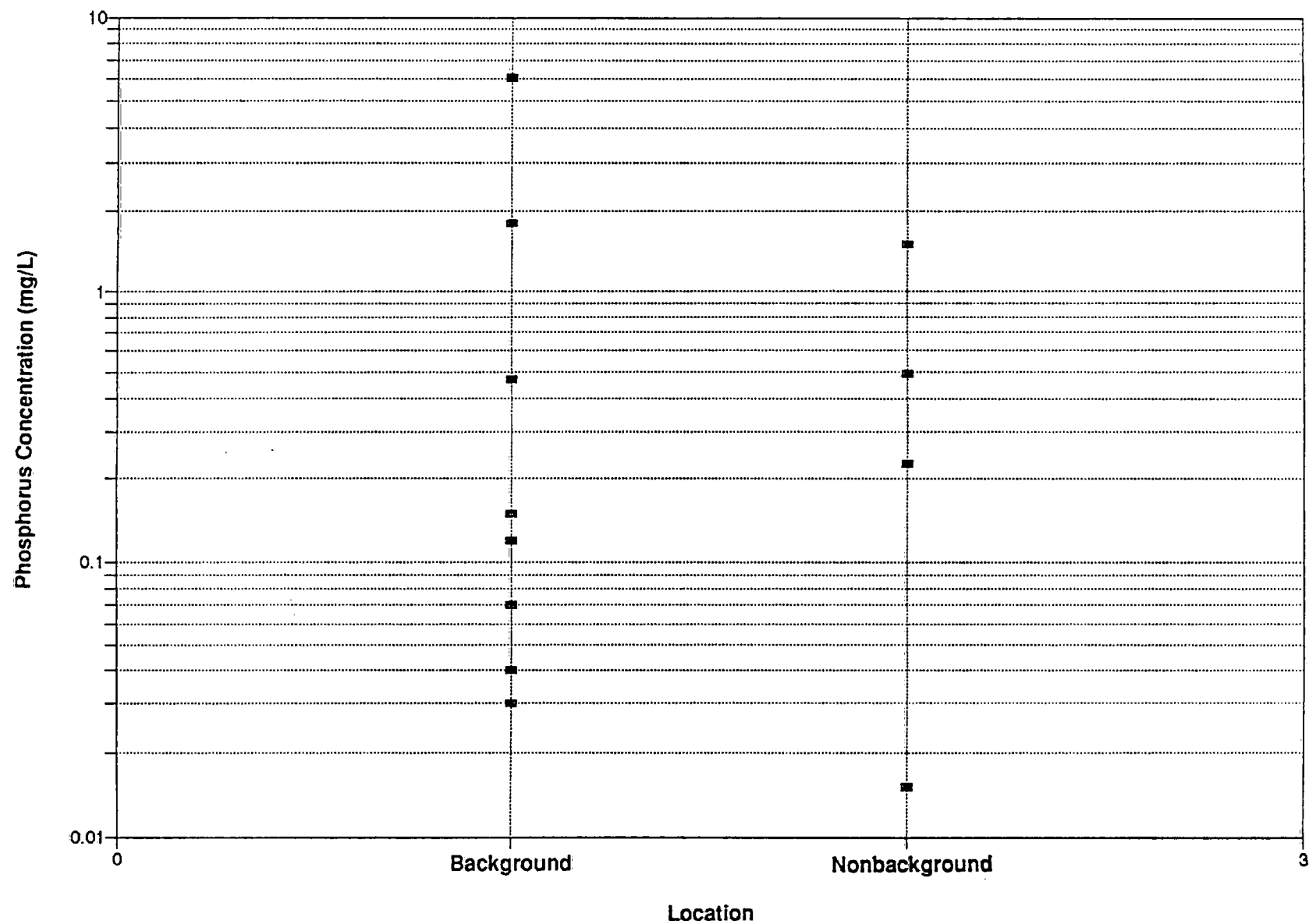






Location of Monitoring Wells Sampled for Phosphorus

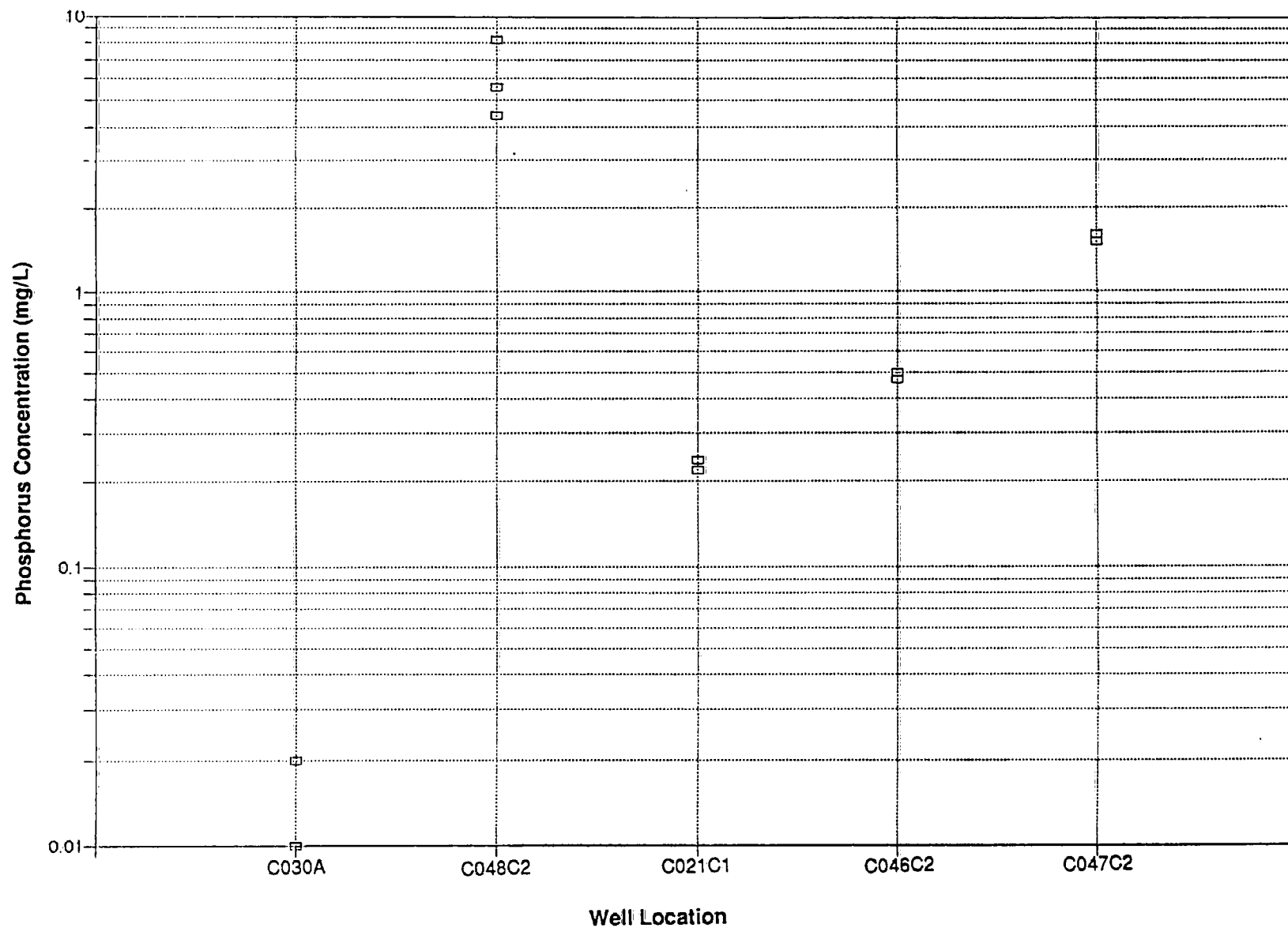
Figure 8



Phosphorus Concentration for Background and Nonbackground Well Locations

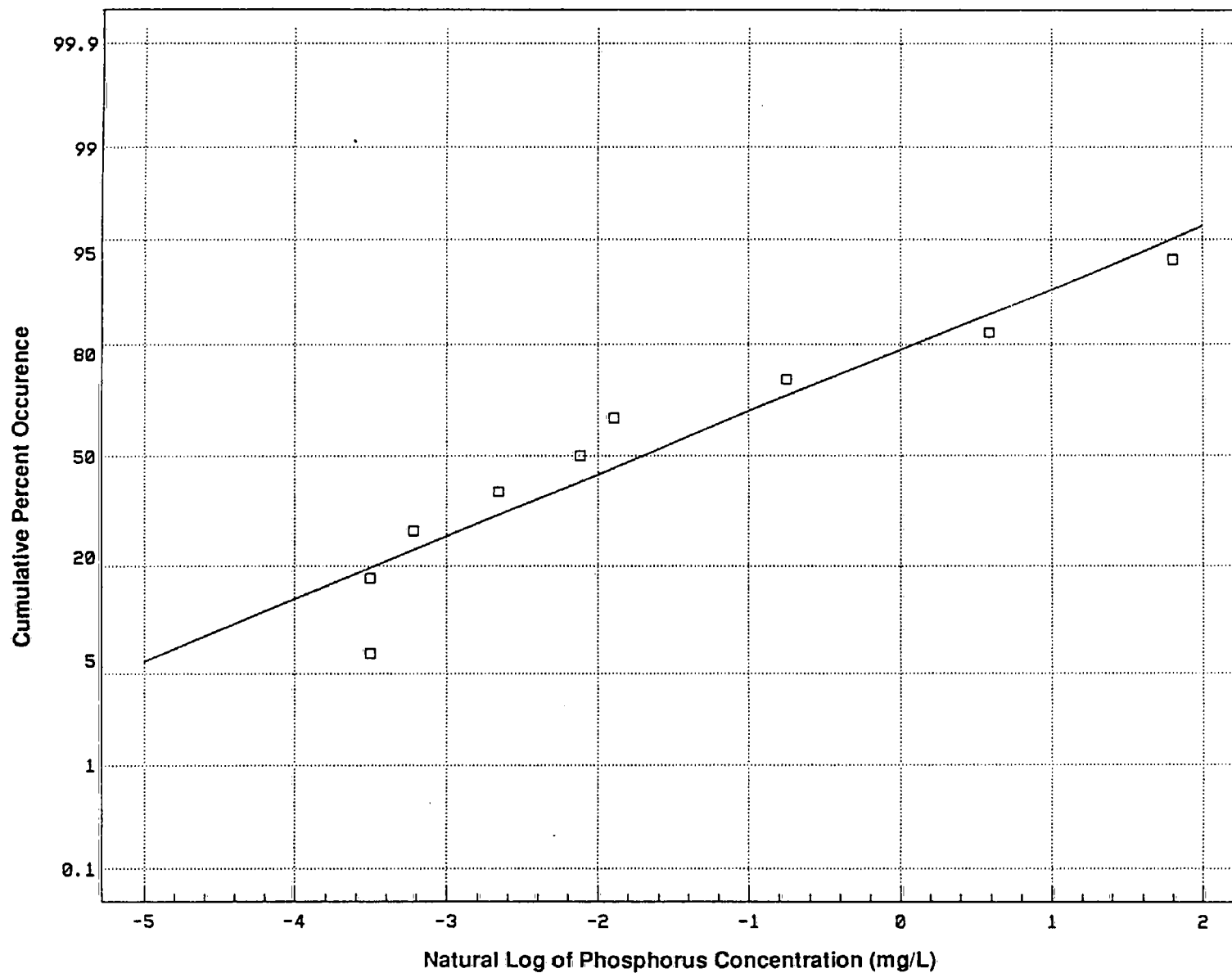
Figure 9





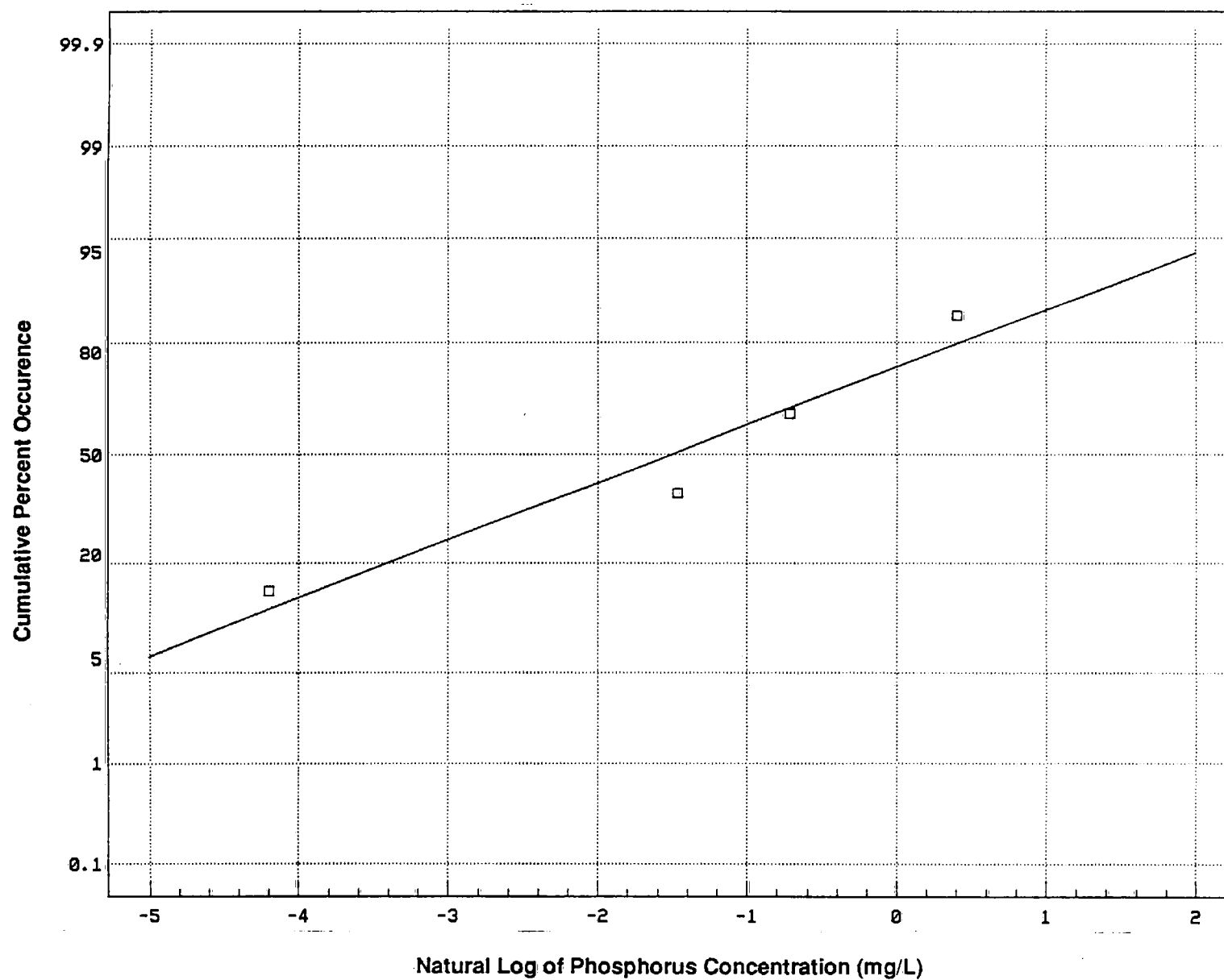
Phosphorus Concentrations for Multiple Sample Well Locations

Figure 10



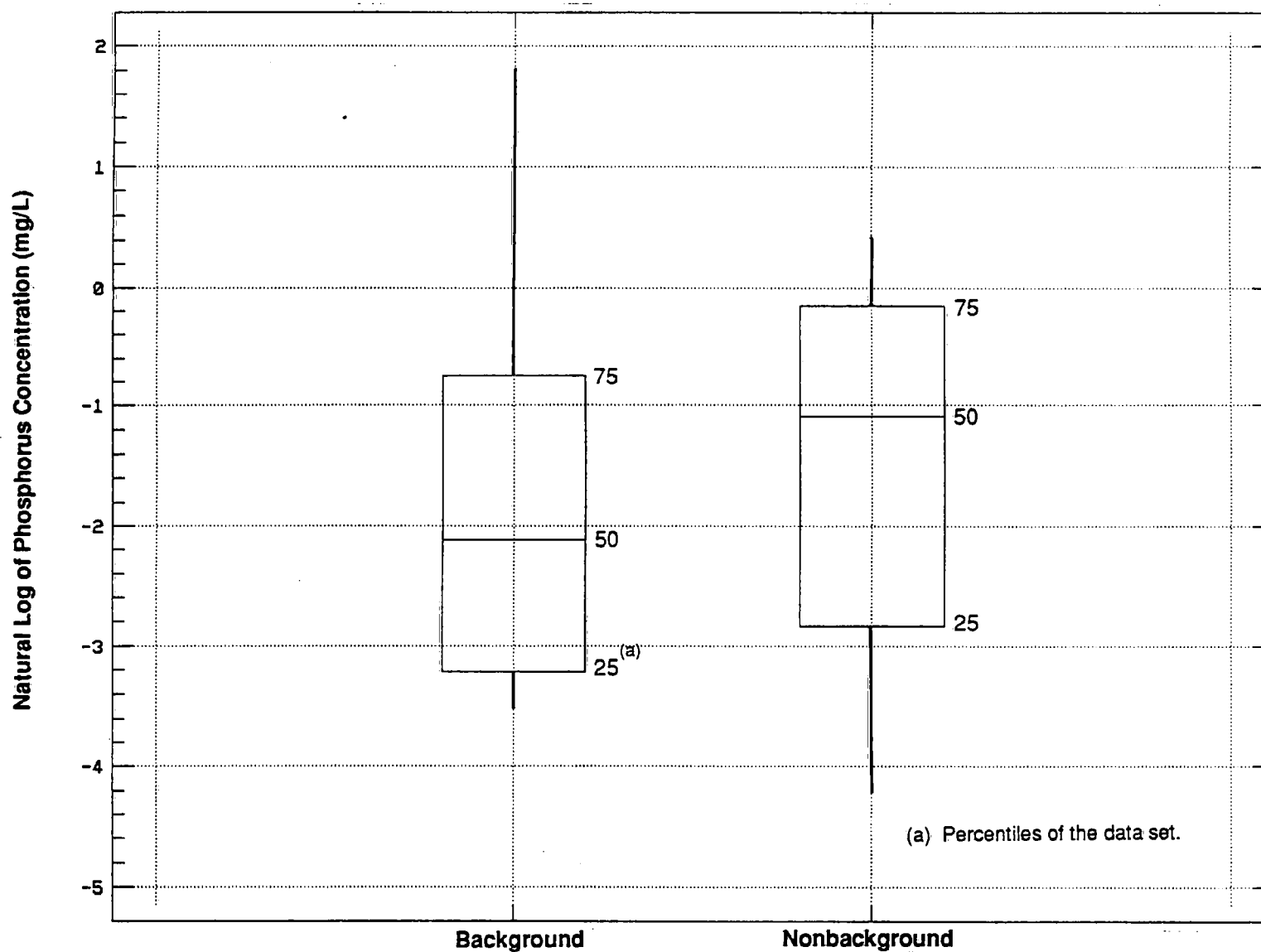
Cumulative Percent Occurrence vs. Phosphorus Concentration - Background Wells

Figure 11



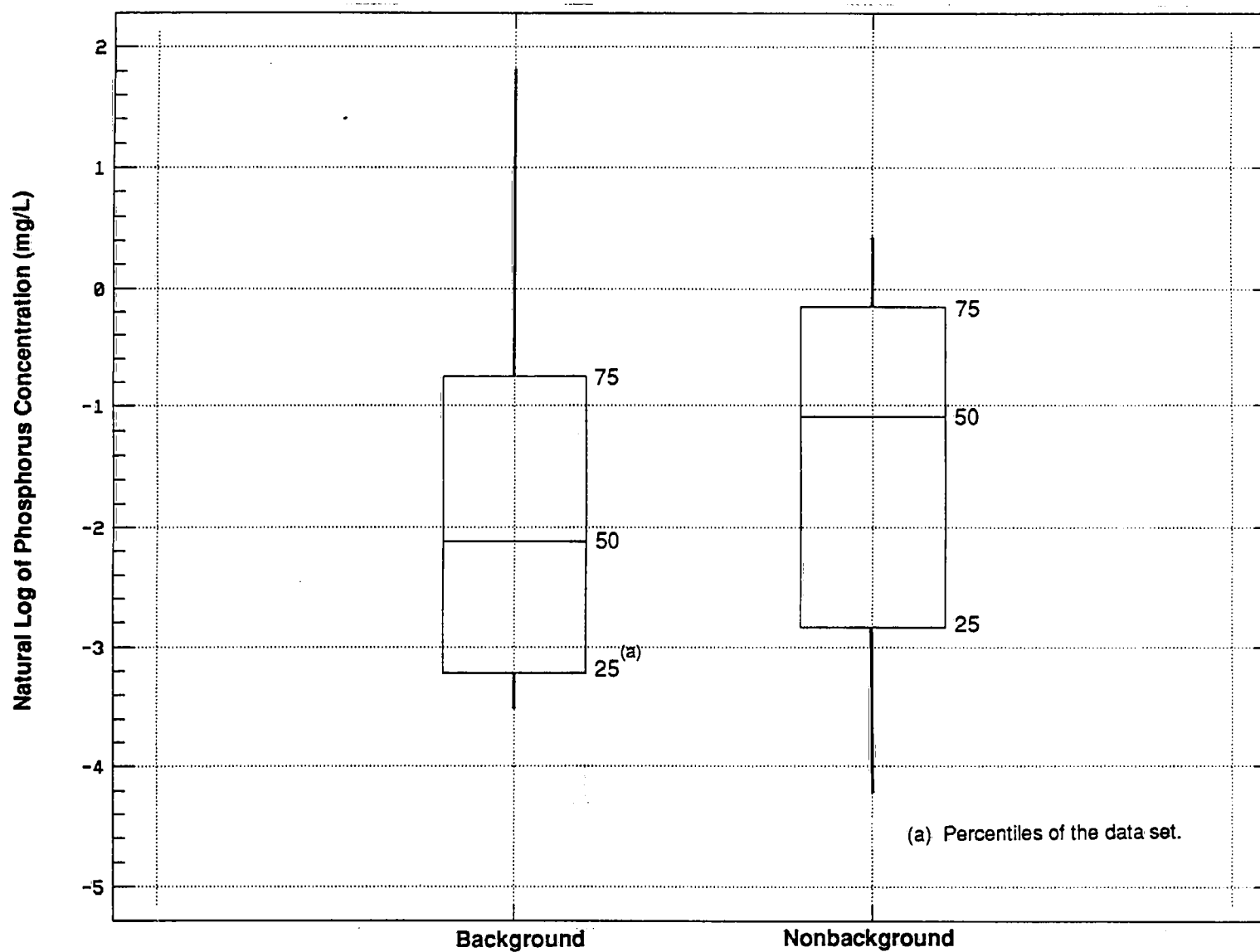
Cumulative Percent Occurrence vs. Phosphorus Concentration  
Nonbackground Wells

Figure 12



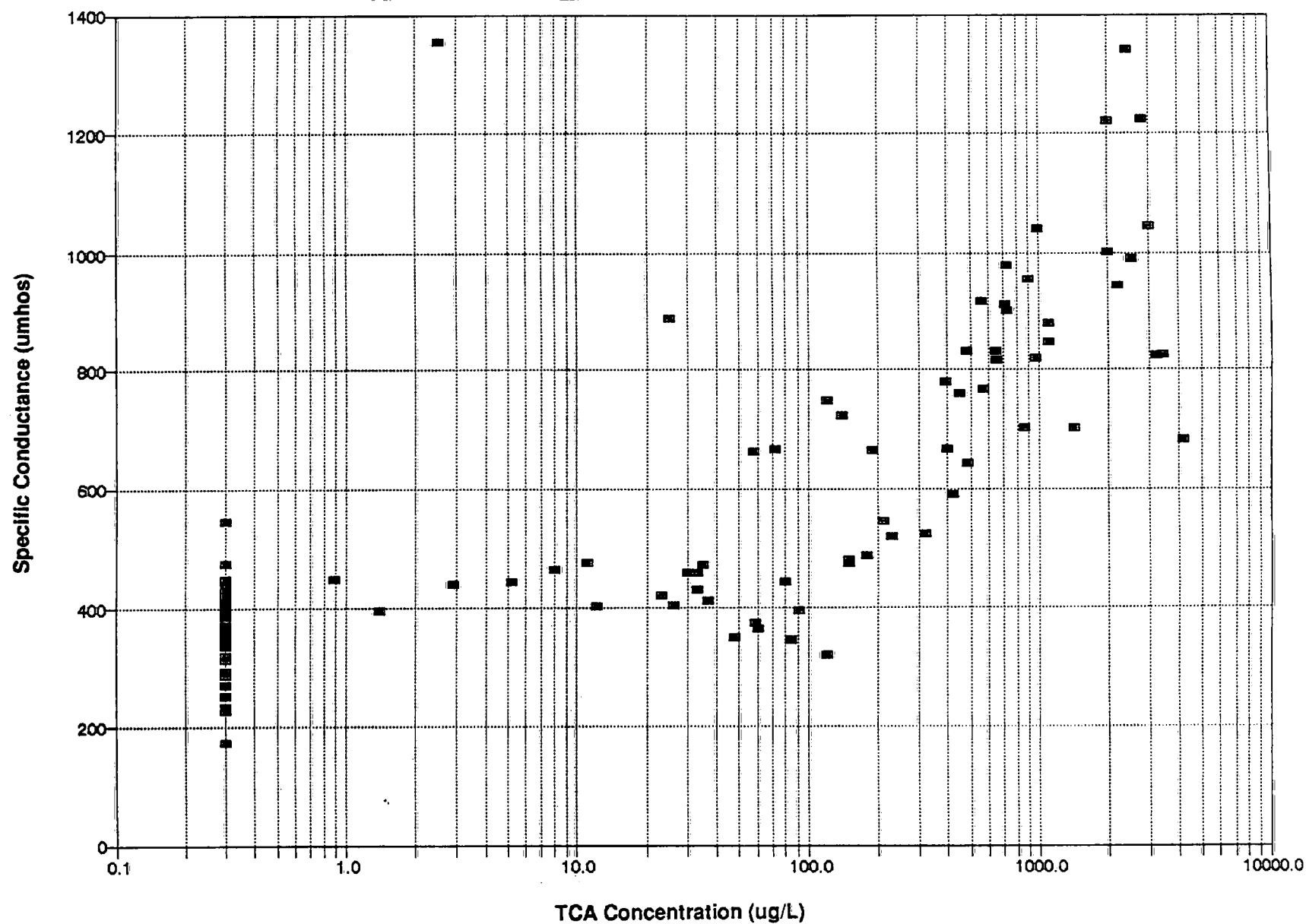
Box Plots for Background and Nonbackground Phosphorus Data

Figure 13



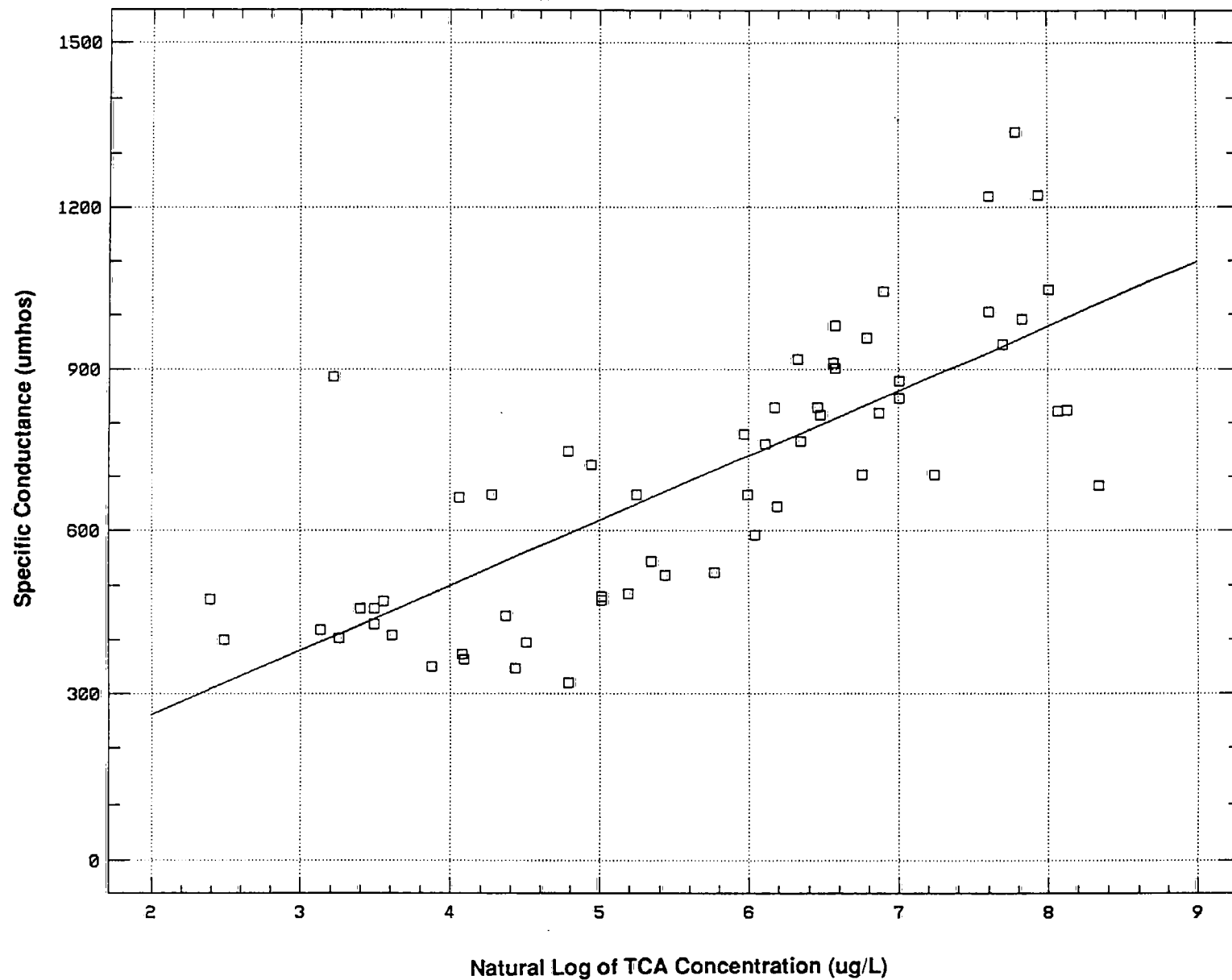
Box Plots for Background and Nonbackground Phosphorus Data

Figure 13



TCA vs. Specific Conductance (Phase I Data)

Figure 14



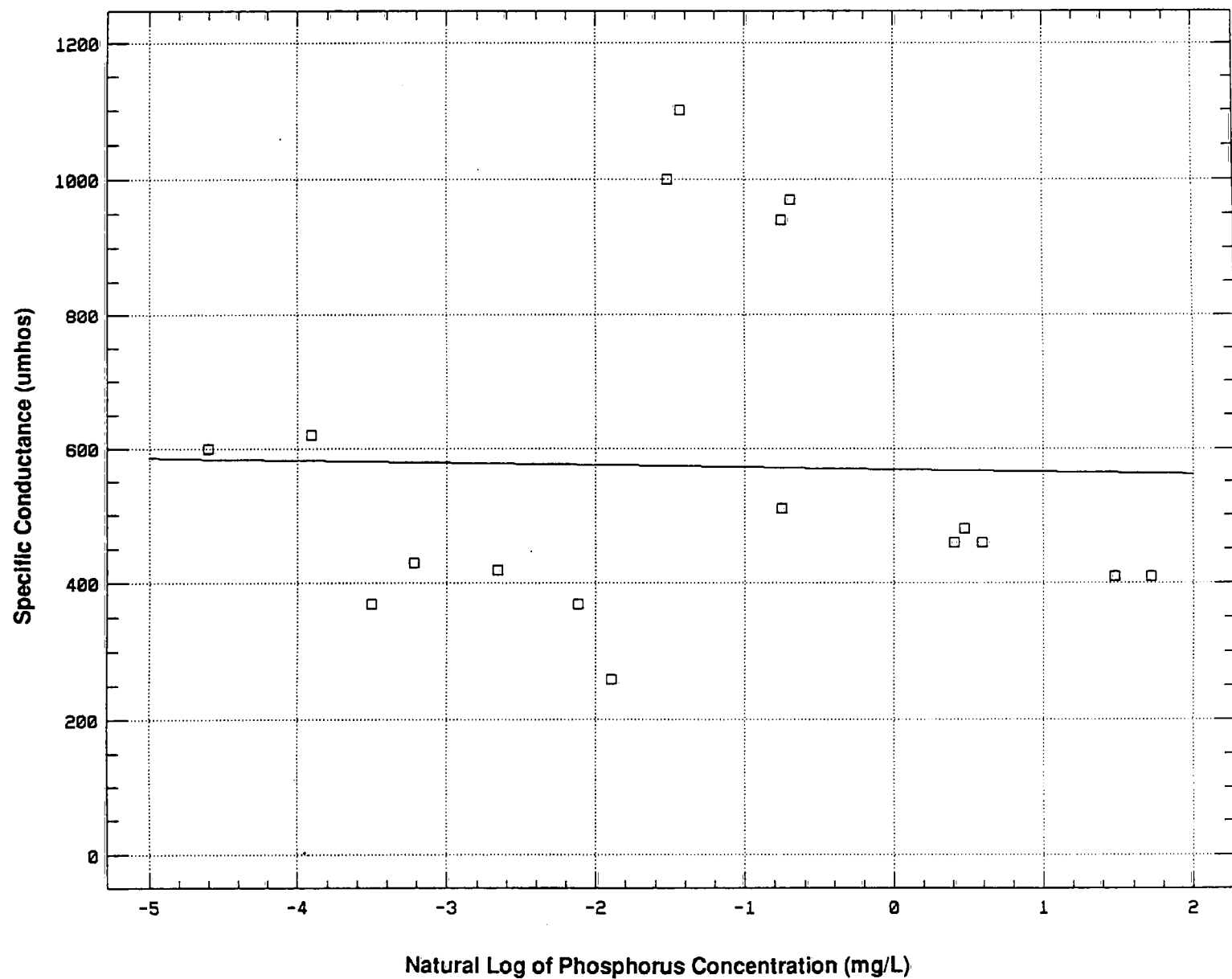
Note: Includes only data where TCA is greater than 10 ug/L.



Regression of Natural Log TCA vs. Specific Conductance

Figure 15





Regression of Natural Log of Phosphorus vs. Specific Conductance

Figure 16

TABLE 1

## SUMMARY OF PHOSPHORUS, pH, AND CONDUCTIVITY ANALYTICAL RESULTS

Sample Location	Sample	Date	Background	Phosphorus	pH	Conductivity
	Number	Sampled	Well	Concentration (a) (mg/L)		
Upper Aquifer						
CD32B1	523	03/01/93	yes	0.07	7.3	420
CD36A	520	02/26/93	yes	0.04	7.5	430
CD38A	525	03/03/93	yes	0.47	7.2	510
CD30A	498	07/22/92	no	0.02	7.1	620
CD30A	512	02/24/93	no	0.01	7.2	600
Lower Aquifer						
CD-5	524	03/03/93	yes	1.8	7.6	460
CD40C2	516	02/25/93	yes	0.15	7.7	260
CD43C2	522	03/01/93	yes	0.03	7.9	370
CD44C2	517	02/25/93	yes	0.12	7.4	370
CD45C2	519	02/26/93	yes	0.03	8.2	370
CD48C2	521	03/02/93	yes	8.2	7.5	410
CD48C2	529 U	03/18/93	yes	5.6	7.5	410
CD48C2 (filtered)	529 F	03/18/93	yes	4.4	7.5	410
CD21C1	494	07/21/92	no	0.24	6.7	1100
CD21C1	513	02/23/93	no	0.22	7.0	1000
CD46C2	514	02/24/93	no	0.47	7.1	940
CD46C2	496	07/22/92	no	0.50	7.2	970
CD46C2 (dup)	497	07/22/92	no	0.50	7.2	970
CD47C2	495	07/21/92	no	1.6	7.7	480
CD47C2	515	02/26/93	no	1.5	7.5	460
CD47C2 (dup)	518	02/26/93	no	1.5	7.5	460

(a) Results are for total phosphorus, except where indicated otherwise.

(b) N/A = not applicable.

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TABLE 2  
RESULTS OF THE SHAPIRO - WILKES TEST  
FOR NORMALITY OF LOG TRANSFORMED DATA<sup>(a)</sup>

Data Set	Confidence Level	Calculated W-Statistic	Tabulated W-Statistic	Conclusion
Background	95 percent	0.886	0.829	Data Log Normally Distributed
Nonbackground	95 percent	0.939	0.748	Data Log Normally Distributed

(a) Results calculated using Lotus 1-2-3 spreadsheets for use with Statistical Guidance for Ecology Site Managers (Blakely 1992).

TABLE 3  
RESULTS OF BARTLETT'S TEST FOR HOMOGENEITY OF VARIANCES  
BETWEEN BACKGROUND AND DOWNGRAIENT DATA SETS<sup>(a)</sup>

Confidence Level	Calculated B Statistic	Attained Significance Level	Conclusion
95 percent	1.00	0.935	Variances are equal

(a) Calculated using the STSC statistical computer package (STSC 1992).

TABLE 4

## RESULTS OF ONE-WAY ANALYSIS OF VARIANCE

Confidence Level	Calculated F-Statistic <sup>(a)</sup>	Tabulated <sup>(b)</sup> F-Value	Calculated Significance Level	Conclusion
95 percent	0.031	4.84	0.86	Accept the null hypothesis

(a) Calculated using the STSC statistical computer package (STSC 1992).

(b) Based on p-1 (1), N-p (11) degrees of freedom and an alpha level of 0.05 where:

p = number of treatment groups (2)

N = total number of data points (13)

alpha level = 1-confidence level (0.95).